Author(s) Still, Kaisa; Huhtamäki, Jukka; Russell, Martha G.; Rubens, Neil

Title Insights for orchestrating innovation ecosystems: the case of EIT ICT Labs and data-driven network visualisations

Citation Still, Kaisa; Huhtamäki, Jukka; Russell, Martha G.; Rubens, Neil 2014. Insights for orchestrating innovation ecosystems: the case of EIT ICT Labs and data-driven network visualisations. International Journal of Technology Management vol. 66, num. 2/3, 243-265.

Year 2014

DOI http://dx.doi.org/10.1504/IJTM.2014.064606

Version Post-print

URN http://URN.fi/URN:NBN:fi:tty-201501201000

Insights for Orchestrating Innovation Ecosystems: Case EIT ICT Labs and Data-driven Network Visualizations

Kaisa Still*

VTT Technical Research Centre of Finland
Kaitoväylä 1
90571 Oulu, Finland
E-mail: kaisa.still@vtt.fi
*Corresponding author

Jukka Huhtamäki

Tampere University of Technology
Korkeakoulunkatu 3
33720 Tampere, Finland
E-mail: jukka.huhtamaki@tut.fi

Martha G. Russell

mediaX at Stanford University
Cordura Hall, 210 Panama Street
Stanford, CA 94305-4115
E-mail: martha.russell@stanford.edu

Neil Rubens

Graduate School of Information Systems
University of Electro-Communications
182-8585 Tokyo, Japan
E-Mail: rubens@ai.is.uec.ac.jp

Abstract: This paper explores opportunities for supporting the orchestration of innovation ecosystems, hence contributing to a fundamental capability in the networked world. We present analysis, evaluation and interpretation toward the objective of decision support and insights for transforming innovation ecosystems with a case study of EIT ICT Labs, a major initiative intended to turn Europe into a global leader in ICT innovation. Towards this, we use a data-driven, relationship-based and network centric approach to operationalize the “Innovation Ecosystems Transformation Framework”. Our results indicate that with coordinated and continuously improved use of visual and quantitative social network analysis, special characteristics, significant actors and connections in the innovation ecosystem can be revealed to develop new insights. We conclude that the IETF transformation framework can be used to develop shared vision and to support the orchestration of innovation ecosystem transformations.

Keywords: innovation ecosystem; network visualization; social network analysis; network orchestration; data-driven; transformation.

Biographical notes: Kaisa Still studies innovation, technology transfer, and the role of technology, with a focus on information and knowledge creation, sharing, and management. Her studies focus on supporting collaboration and cooperation in organizations as well as in community settings. Recent studies include mobile, online and social networking communities, innovation ecosystems, and innovation indicators. Dr. Still has over 10 years of cross-sector business and academic experience in Finland, USA and China. She currently works for VTT Technical Research Centre of Finland and is a founding member of Stanford's Innovation Ecosystems Network.

Jukka Huhtamäki (M.Sc, Hypermedia) is a researcher and a teacher at the Intelligent Information Systems Laboratory (IISLab) at Tampere University of Technology and a founding member of the Innovation Ecosystems Network. His interests include the methods, processes and tools of data-driven visual analytics, social network analysis, and the development of modern hypermedia. Currently, Huhtamäki is working to develop means and methods of data-driven visual network analytics for insights on the structure and dynamics of innovation ecosystems. He is also preparing a PhD on the topic.

Martha G. Russell is Senior Research Scholar at Human Sciences Technology Advanced Research Institute and Executive Director of mediaX at Stanford University, a membership-based, interdisciplinary research catalyst focused on people, media, technology, and innovation. Dr. Russell's background spans a range of business development, innovation, and technology-transfer initiatives in information sciences, communications, and microelectronics at the University of Minnesota, The University of Texas at Austin, and Stanford University. She is a founding member of Stanford's Innovation Ecosystems Network and serves on the editorial board of the Journal Technology Forecasting and Social Change.

Neil Rubens is an Assistant Professor at the Knowledge Systems Laboratory, University of Electro-Communications, Japan. He is the Director of Active Intelligence Research Group and is a founding member of the Innovation Ecosystems Network at Stanford University. He holds an M.Sc. degree from the University of Massachusetts and a Ph.D. degree from the Tokyo Institute of Technology - both in Computer Science. His research focuses on developing Active Intelligence systems, which are Artificial Intelligence systems that are self-adaptable utilizing unsupervised and semi- supervised learning, and active communication and data acquisition.

This article is a revised and expanded version of a paper entitled "Transforming Innovation Ecosystems through Network Orchestration: Case EIT ICT Labs" presented at XXIII ISPIM Conference, Barcelona, Spain, 17-20 June 2012.

1 Introduction

This study is motivated by the pursuit of network-based findings to reveal new insights on how interventions can be orchestrated to facilitate transformation of an innovation ecosystem. Our study is based on the understanding that firms are embedded in networks of relationships that remarkably affect their potential success in the markets (Ritala et al.

2009). These complexities related to innovation have increasingly been addressed with the term ecosystem (Durst and Poutanen, 2013). Orchestration, or network orchestration, refers to capability to purposefully build and manage inter-firm innovation networks (Dhanaraj and Parkhe, 2006); when network-level, collective gains are sought, organizations seek to assemble or orchestrate networks and manage their growth (Paquin and Howard-Grenville, 2013), which we explore in the context of innovation ecosystems.

In this study, we show how data-driven network visualizations can be used to produce insights for orchestrating innovation ecosystems. Our data-driven approach stems from the potential of the vast sea of available data, which can be referred to as information overload or as big data; it is also touted as the next frontier for innovation, competition and productivity (McKinsey, 2011). Big data is seen to provide possibilities for promoting better measurement, better management and better decisions (McAfee and Brynjolfsson, 2012). For this study, we see that openly available data about innovation, coupled with its analysis and presentation, provides possibilities for insights that can promote better measurement, better management and better decisions in the context of innovation ecosystems. The network visualizations demonstrate how connections at the level of the individual nodes and links can have complex effects that ripple through the ecosystem as a whole (Easley and Kleinberg, 2010).

Network orchestration is an understudied process with mainly conceptual studies addressing it (Ritala et al., 2009). A better understanding of it is considered of both scholarly and practical importance (Paquin and Howard-Grenville, 2013) for "an integrated understanding on the mechanisms for value creation and capture in the innovation ecosystem context" (Ritala et al., 2013: p. 246). Hence, in this study we attempt to provide empirical qualitative and quantitative evidence for supporting network orchestration in the form of data-driven network visualizations. In addition, we demonstrate how these visualizations can be used to produce insights for orchestration for innovation ecosystems. We explore the possibilities for supporting understanding, monitoring and managing innovation ecosystems and their transformations, using innovation ecosystem transformation framework (IETF), which has been previously and successfully used to create insights on network orchestration (Russell et al., 2011).

The structure of the paper is as follows: we begin with an overview on previous studies from which our approach is derived, then we describe the data sample and its analysis, which allows us to discuss the insights based on the findings, as well as the opportunities they provide for orchestrating transformation. Finally, we present recommendations for replication and extension of this approach, and we describe limitations of our study. Overall, with this research we invite researchers, program managers and policy makers to embrace the value of understanding and measuring complex relationships underlying innovation in a networked world.

2 Theoretical background

2.1 Innovation Ecosystems

Sustainable innovation activities are rarely carried out by a single individual or within a single organization; they are sometimes addressed with the ecosystem approach. Innovation ecosystems, generally seen as entities consisting of organizations and connections between them, have been defined as human networks that generate extraordinary creativity and output on a sustainable basis (Hwang and Horowitt, 2012) and also as consisting of interdependent firms that form symbiotic relationships to create and deliver products and services (Basole and Rouse, 2008). A broader definition sees innovation ecosystems as a network of relationships through which information, talent and financial resources flow through systems, creating sustained value co-creation (Russell et al., 2011), including human networks and firm-level networks as well as the "inter-organizational, political, economic, environmental and technological systems of innovation through which a milieu conducive to business growth is catalysed, sustained and supported" (Russell et al., 2011: p. 3).

Networks are described by connections, or social links (Krackhardt and Hanson, 1993) and as nested structures of individuals, firms, and their relationships (Halinen et al., 2012). Addressing ecosystems as networks allows studying their complex relationships, providing means for mapping the ecosystem structure to support its monitoring and management, sometimes addressed as orchestration. Also from the policy side, networks have been at the centre of attention. The significance of actors and the relationships between them have become targets for innovation policy, under "the rationale for network formation and for their support is the assumption that the whole (the network) is greater than the sum of its individual parts (the network members) in terms of the activities performed" (Cunningham and Ramlogan, 2012).

The utility of network modelling for studying innovation ecosystems comes from the revelation of patterns of connections and interactions within an ecosystem that are captured (Green and Sadedin, 2005) and revealed as structures. Social network analysis (SNA) studies the structure of networks of social actors (Wellman and Berkowitz, 1988). SNA has been used to study the sociological relationships of people and organizations (Wasserman and Faust, 1994; Welser et al., 2007). For example, node degree is the simplest metric for centrality and connectivity. Degree value shows the number of direct connections of a node (Wasserman and Faust, 1994). Betweenness is another centrality metric useful for measuring the importance of a node's bridging role in a network; betweenness value represents the number of times a particular node is in the shortest path for any node-pair in the network (Wasserman and Faust, 1994).

With the rise of consumer-generated content, SNA has been deployed to analyze communication structures, content and virality in social media (Welser et al., 2007) and promises to do so also for other sources of big data. Recently, Liu, Slotine and Barabási (2011) have shown that understanding the structure of a network is a key factor in the controllability of both engineered and real complex networks.

2.2 Orchestrating transformation

The concept of network orchestration goes beyond both knowledge management and innovation management, to include "discrete influence" that addresses the interdependencies and flexibility of actors in the network (Rizova, 2006). This perspective enables coordination of the innovation network and signals for the innovation output (Dhanaraj and Parkhe, 2006). Increasingly, networks are intentionally "orchestrated" or "engineered" by an organizational actor who recruits network members and shapes their interactions, corresponding to phases of innovation ecosystem building and management (Ritala et al., 2013); the impacts of such orchestration have been shown to be pervasive, robust and long-lived (Paquin and Howard-Grenville, 2013). The ability to connect and manage competences across a broad network of relationships has also been seen as one of the most important meta-capabilities for a networked world (Wind et al., 2008; Ritala et al., 2009). In accordance, there have been many programs of government interventions to create and support networks (Cunningham and Ramlogan, 2012).

The capacity to continually co-create and maintain value is essential (Christensen, 1997). To fully explore the processes in innovation ecosystems that are enacted through time and how nested network structure shapes the process, Halinen et al. (2012) recommend examining relationships and interactions. Furthermore, network orchestrators are urged to engage in sensemaking for external audiences who have little or no prior understanding of the transformation activity and its "rightness" (Möller and Rajala, 2007).

The goal of network orchestration is guided transformation of the ecosystem with continuous co-creation that allows the evolution of the processes needed to motivate and realize the transformation (Russell et al., 2011). This process evolution accommodates the complex influences on innovation in a networked world, and energizes innovation processes and outcomes. Through the lens of the Innovation Ecosystems Transformation Framework (IETF), a shared vision of the transformational potential of a dynamic innovation ecosystem is created through changes in actors, the events that they enable and the coalitions reflected in their relationships. The infrastructure of the network evolves through their coalitions, accommodating and stimulating innovation in line with their objectives and the collective shared vision. Actors perform roles as arbiters, catalysts and gatekeepers in open and closed-elite dynamics across time. (Powell and Owen-Smith, 2013.)

Figure 1 Innovation Ecosystems Transformation Framework (IETF)

The Innovation Ecosystems Transformation Framework (Figure 1) is based on the premise that shared vision for transformation in an innovation ecosystem is created and continually updated through relationships that motivate and guide decisions to realize that vision. Hence, it simultaneously calls for and allows for action research, which "seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions for pressing concern to people, and more generally the flourishing of individual persons and their communities" (Reason and Bradbury, 2001, p.1). It extends the process studies of change in organizations that "conceptualize change as a succession of events, stages, cycles or states in the development or growth of an organization" (Van De Ven and Poole, 2005, p. 1389) to transformation as a process that is continually updated and collectively realized, as suggested by Hagel and Seely Brown (2005). It further recognizes that shared vision is a significant resource (Hagel and Seely Brown, 2005) for innovation ecosystems. Every decision point for effective change cannot be discussed and approved in committee or agreed before implementation. Across the constituents of change, many critical decisions must be made individually and independently. It is the shared vision of these decision makers that allows their independent decisions to synergize change and transform the present into to a shared future.

People and other resources, referred to as actors, participate in events that over time effect changes in the initial conditions; one such change is the emergence of new coalitions, through which joint participation reveals their relationships, shown as links between the actors. Changes in the actors and changes in their links document modifications in the network and the coalitions that provide its structure. Over time these shifts result in new actors, new events, new impacts and new coalitions that continuously evolve into the shared vision of the future

Previously the IETF has been used to measure, track and visualize snapshots of regional innovation ecosystems. For example, mapping the local events and participants of projects supported by the Southeastern Minnesota Initiative Fund's regional development revealed the emergence of a regional perspective as community organizations began to include newsletter coverage of events sponsored by related organizations in the region (SEMIF Regional Development Planning and Evaluation Report, 1990.) The programmatic and financial support networks for afterschool programs in Dallas County, Texas revealed the accomplishment of shared vision in the programmatic strength of afterschool programs that relied on multiple sources of support, which in turn provided similar types of programmatic services in addition to their financial supports (Russell and Smith, 2011.) Relationships between CapDigital companies jointly applying for and receiving government funding awards highlighted the ecosystem growth of a network of Parisian companies pursuing new opportunities, as well as programmatic opportunities for further accelerating regional transformation (Russell et al., 2011.) Insights about these successes and opportunities, when shared in interactive visual format with the CapDigital Board of Advisors, stimulated ideation and actions to mobilize support for new initiatives (personal conversation with Patrick Cocquet, Cap Digital, Paris, France, 9 October 2013.)

2.3 Data-driven network visualization

Calculating network metrics and tracing their changes over time are methods that have been used to study the longitudinal processes of network orchestration (Paquin and Howard-Grenwille, 2013). As access to and availability of unprecedented amounts of data about the complex innovation ecosystem and its parts now exist, network visualizations have evolved to a data-driven process (Nykänen et al., 2008) with phases of data collection, refinement, analysis and visualization (Card et al., 1999). Visual network analysis affords insight into the social configurations of the networks and assists in communicating the findings to others (Freeman, 2009). Hence, visualizations can help us "see through the forest of data". They are more than pretty pictures as they allow for real-time exploration of complex, interacting variables (Hadnazy, 2011) and can provide evidence about ecosystem transformation and opportunities for orchestrating this transformation.

The data-driven process starts with data, which can exist in: official company data; compiled through surveys; and as organizational data about collaborations and activities within the company and outside the company. Much of this data is proprietary and not easily available. However, information created and shared in social media also exists. This socially constructed data is created as innovation actors, such as company founders, entrepreneurs, knowledge and financial investors, journalists, policy makers and customers, use social media to share information, discuss events and communicate about their needs, experiences and opinions related to innovation (Still et al., 2012). For example, companies issue press releases and blog about their activities, results of their funding rounds, and new personnel. Their information is picked up and added to publicly available sources such as Wikipedia, TechCrunch, CrunchBase, Arctic Startup, and AngelList. Socially constructed data has the characteristics of open access and availability, potentially large coverage, timeliness, and community verification of data quality. Some of the disadvantages are the potential of incompleteness and inconsistency, lack of established perspective, and the issue (although slightly different from that of officially curated data) of incompleteness and inconsistencies. This data, sometimes referred to as "big data", is by default in digital format which, combined with computational power available today, provides potentially revolutionary business intelligence for business advantage and performance improvement, and for management decisions based on evidence rather than intuition (McAfee and Brynjolfsson, 2012).

This kind of data can be arranged as relational data to define the relationships within an ecosystem and can be used to create network representation of the ecosystem. The relational context of this data allows the use of SNA metrics. To present the data as a network and its metrics in a visual form, we compiled a set of tailored batch-processing tools in Python for network creation. Moreover, we used Gephi for calculating network metrics as well as for network visualization and layout. The network layout was created using a force-driven algorithm in which nodes repel each other and the links pull the connected nodes together (Noack, 2009). The resulting network layout reveals the clusters in the network as well as the key nodes and pathways that build bridges among the clusters.

Hence, data-driven network visualizations can be seen to offer a powerful approach to providing evidence-based information when talking about ecosystems, their structures, actors, and interactions. The visualizations can reflect the structure of an innovation ecosystem at a single point in time, and they can also show the evolution of an ecosystem's actors and their relationships over time (Basole et al., 2012).

3 Methodology

The objective of this research is to explore how data-driven network visualizations can be used to produce insights for orchestrating an innovation ecosystem. The innovation ecosystem transformation framework (IETF) is used to translate, or understand, the ecosystem to empower change agents to measure and transform it with network orchestration, extending the process studies of change (Van de Ven and Poole, 2005) to include relationships of co-creation. Our operationalization of IETF includes measuring and tracking through socially constructed data and using network analysis metrics and visualizations to implement the sensemaking and feedback mechanism. These correspond to network orchestration actions that are seen to shape network structures and outcomes, which in turn create shifts in orchestration actions (Paquin and Howard-Grenville, 2013). We see value in this activity, even though (1) we are aware of the confines of the IETF due to the inherent characteristics of all frameworks as simplified models, and (2) we acknowledge that data-driven visualizations rely on data and that our data is not complete and hence the resulting network visualizations cannot show all of the connections nor nodes and might be seen incomplete for the purposes of network orchestration.

In this study, we employ a case study of EIT ICT Labs to demonstrate the use of IETF for addressing how data-driven network visualizations can be used for orchestrating innovation ecosystems. The case study method has been found to be a legitimate way of adding to the body of knowledge by providing detailed and analysed information about real world environments which can be seen as examples of phenomena under research (Benbasat, 1987). Due to the call for practical solutions for the EIT ICT Labs community, through employing the IETF, we follow action research practices towards combining the expertise of evidence-based research with local, contextual knowledge (Brydon-Miller et al., 2003).

Accordingly, we actively communicated and collaborated with EIT ICT Labs representatives of two senior managers and one business developer. These representatives are knowledgeable and have a holistic understanding of the context, thus using them as informants was seen applicable, especially as they are interested and open to collaboration. These informal, unstructured and iterative discussions took place through face-to-face meetings and online meetings, were short (maximum of 1 hour) and were documented in notes. The discussions were conducted in the summer of 2011 for validity checks after initial data analysis, in the summer of 2012 for refinement of visualizations, and in the fall of 2013 for collaborative sensemaking after the release of the final versions of the visualizations.

Within EIT ICT Labs it is recognized that relationships between key individuals open channels through which talent, information and financial resources can flow across Europe. This flow of resources – as relational capital – through relationships is a key premise of IETF; in this study we refer to this flow as mobility. Mobility is widely recognized as an important aspect of knowledge creation and sharing within innovation networks (Saxenian, 2007), and its use as the indicator for the exchange and innovation potential in the economy is recognized (Graversen, 2003). We focus on changes in relationships during a 3-year period as an indicator of mobility, with which we measure and track the process of transformation. Therefore, we use SNA metrics of degree and betweenness as a mobility factor to illuminate the potential of individual nodes to serve as bridges between the EIT ICT Labs co-locations. The resulting metrics and visualizations (geospatial network representations) provide evidence on ecosystemic actors and linkages that create the context of mobility for the EIT ICT Lab as well as reveal the operational impact of its activities act as events whose impact can create new coalitions that will serve as conduits for the mobility of information, talent and financial resources. Insights connecting events to coalitions can be used for creating shared understanding and program planning for the management of networks in this emerging innovation ecosystem.

3.1 Case EIT ICT Labs

EIT ICT Labs (http://eit.ictlabs.eu) operates in a complex ecosystem of independent and interdependent actors, financing schemes and business models that create value for the European innovation landscape, and whose innovation strategy is positioned toward its mission of enhancing this ecosystem to synergize and accelerate innovations contributing to economic growth. (http://www.eitictlabs.eu/ict-labs/about-eit-ict-labs/our-approach/.) For the purposes of our research, we view EIT ICT Labs as an innovation ecosystem and apply IETF to its transformation:

- with the shared vision of turning Europe into the global leader in ICT innovation
- with coalitions of subnetworks of actors - "nodes" - and the various actors around them

- participating in events (collaborative activities and interactions shown by "links") that result in impact (changes) in the flow of company information, of talent and of financial and other innovation resources
- looking at relationship links as indicators of the potential to increase the mobility of information, talent and resources.

For validation of the ground truth of our datasource and for feedback on opportunities for transformation, we collaborated with representatives of EIT ICT Labs. We presented our early results and initial sensemaking to them, allowing them as context-experts to engage in their own sensemaking of the findings and to derive the insights needed to support decisions regarding network orchestration.

3.2 Data collection and sample characteristics

The analysis of the ecosystem of EIT ICT Labs uses an annual sampling of Innovation Ecosystems Network (IEN) Dataset (Rubens et al., 2010), which is a quarterly updated collection of socially-constructed and curated data. It is data scraped from sources such as Crunchbase, TechCrunch, Arctic StartUp, Wikipedia etc. that has been cleaned and organized so that it can be used for further analysis. The dataset for this study describes executive and funding relationships, which then allows for the network visualizations: it includes data on companies (including enterprises and startup companies), their key individuals (with data about the educational institutions they have been associated with), and their financing firms (investment organizations and venture capital investors). Individuals in the dataset are key individuals in their respective companies (e.g. founders, executives, lead engineers, members of boards of advisors, and investors). As shown in Table 1, the full dataset from which the EIT ICT Labs sample is drawn includes more than 100,000 companies.

Table 1. Full dataset over selected time periods

Network actor	***2011***	***2012***	***2013***	***2011-2012***	***2012-2013***
Individual	76,000	100,000	150,000	32%	50%
Company	65,000	80,000	100,000	23%	25%
Financial	5300	7,000	10,000	32%	43%

The dataset for the EIT ICT Labs sample is drawn by selecting all the companies that have their primary office in one of the 6 co-location cities of EIT ICT Labs: Berlin, Eindhoven, Helsinki, Paris, Stockholm, and Trento. Each company is connected to the city of its primary office with a link. Then, we select all the key individuals (founders, board members and C-level executives) in the dataset that are identified either with a previous or a current connection to one or more of the companies in the sample and showed their relationship to those companies with a link. Next, financial organizations identified with funding events for those companies are added as nodes, and the relationships between financial organizations and companies are shown with additional links. These procedures were used to create a sample of IEN data for EIT ICT Labs, first in 2011, the year the EIT ICT Labs program was initiated. Same procedure was used in

2012 and 2013 to recreate those samples of EIT ICT Labs data from the updated IEN dataset.

Intrigued with how relationships with international companies, key individuals and especially financial organizations might reveal new insights about the EIT ICT Labs innovation ecosystem, we expand the year 2013 sample to include the ICT companies in the San Francisco Bay Area of California, then also include the individuals and financial organizations that have relationships with those companies. Using the same data selection procedures as for the initial sample, links to actors in the EIT ICT Labs sample are established based on relationships such as board or advisory roles (individuals) or investments (financial). This expanded sample introduces more than 6,800 companies, almost 20,000 key individuals and some 1800 financial firms from SF Bay Area to the overall ecosystem. The expanded sample adds the relationships of the San Francisco Bay Area to the EIT ICT Labs network, revealing its potential to enhance the mobility of information, talent and financial resources.

3.3 Network Metrics and Visualizations

To present evidence of the ecosystemic transformations taking place in the European innovation ecosystem and measuring and tracking the EIT ICT Labs ecosystem, we utilize network metrics of degree and betweenness that are also basis for the data-driven network visualizations. Especially betweenness supports the understanding of existing connections between innovation nodes, and also provides potential insights for targeted actions based on the innovation actors with highest betweenness values.

Overall representation of the EIT ICT Labs network across co-location cities is created (Figure 2). In this, we include and examine key individuals, companies, and investors. The lines between the nodes show links–relationship connections (total number of nodes is 6187, total number of links is 7050). A company is linked to a co-location city if its primary office is located in the city. In all of the visualizations, key individuals are in blue, companies in red, and financial firms in green. The names of individuals, companies and investors are not shown. Link color follows the color of the source node. Gray links point from EIT ICT Labs co-locations to companies, green links from investors to companies, and blue links from individuals to companies. To more clearly reveal key patterns in the structure of the EIT ICT Labs innovation ecosystem, actors in each co-location having the top 10% betweenness values are selected across all node categories, i.e. individuals, companies and investors. The top 10% network includes 29 individuals, 51 investors and 513 companies that form the key pathways in between the six EIT ICT Labs co-location cities. Node size is again proportional to its betweenness value.

Companies are initially clustered close to their respective EIT ICT Labs co-location cities. However, the force-directed layout algorithm pulls the company toward other locations based on links to locations established through individuals or investment firms who have relationships with multiple companies in different locations. Similarly, this algorithm pulls the location of financial firms to a place in the network that reflects all the relationships with companies held by that firm. In this way, nodes representing companies, financial firms and key individuals are positioned relative to each other, in the context of the companies' connection to the EIT ICT Lab co-location cities. In the resulting network visualization, many actor nodes are clustered around each of the co-location cities. Paris and Berlin show the largest clusters because they have the greatest number of actors–key individuals, companies and financial firms–connected to them. They share connections, which pulls them close to each other, and Paris with its multiple and powerful connections takes its central place in the EIT ICT Labs ecosystem.

4 Results

This research analyzes mobility in the context of relationships between companies, individuals and financial organizations in the innovation ecosystem based on the co-location cities in which the EIT ICT Labs initiative is operating.

4.1 Network metrics

The size of the EIT ICT Labs ecosystem increased from 2011 to 2013 as presented in Table 2. Compared to the analysis conducted in 2011, the number of companies in the EIT ICT Labs sample dataset in 2012 and 2013 increased at approximately the same pace (23%) as the number of companies in the IEN Dataset as a whole (25%). The changes in number of key individuals as well as investors are different in the full dataset compared to the sub-set for EIT ICT Labs. This interesting trend deserves more analysis, and could be a result of changes in the online availability of data rather than changes in activities of actors. However, for the purposes of this research, we concentrate on changes within case EIT ICT Labs. For example, a total of 55 new investors emerge in its network between 2012 and 2013.

Table 2 Growth over time of EIT ICT Labs ecosystem sample dataset

Network actors	***2011***	***2012***	***2013***	***2011-2012*** Change	***2012-2013*** Change
Individual	1,634	2,817	3,660	72%	30%
Companies	1,056	1,665	2,041	58%	23%
Financial	280	425	480	52%	13%

Table 3 shows the changes in degree and betweenness metrics across the EIT ICT Labs co-location cities during the 2011 to 2013 period. Berlin and Paris have the greatest connectivity; in this innovation ecosystem these co-location cities have the largest number of actors connected to them. In 2013, the sample reveals that Paris had 589 companies in the ICT sector; Berlin had 507. This is roughly twice the number of Eindhoven, Stockholm and Helsinki and more than five times more than Trento. Paris and Berlin exhibit the greatest betweenness values in 2012 and continue to have the greatest betweenness values in 2013 (9,762,717 and 8,159,381, respectively).

Table 3 Change over time in relationship metrics for co-location cities

	Betweenness	***Degree***

Co-location cities	*2012*	*2013*	*Change*	*2012*	*2013*	*Change*
Paris	6,950,362	9,762,717	40%	505	589	17%
Berlin	5,284,815	8,159,381	54%	389	507	30%
Eindhoven	2,802,845	4,445,841	59%	202	257	27%
Stockholm	2,695,012	3,978,408	48%	230	273	19%
Helsinki	2,741,119	3,914,762	43%	230	264	15%
Trento	820,993	1,246,415	52%	56	71	27%

The largest change in betweenness values is observed in Eindhoven and Berlin, 59% and 54%, respectively). These co-location cities show the greatest positive changes in betweenness and the largest increases in degree value since 2011. Trento follows closely with an increase of 52% in its betweenness and an increase of 27% in its degree of connectivity.

4.2 Visualizations

In the network visualization shown in Figure 2, Paris and Berlin occupy key roles in the ecosystem; financial organizations (green) occupy central positions between co-location cities and thus are revealed as key enablers for mobility.

Figure 2 Key individuals, companies and financial firms as resources for mobility in 2013

The size and complexity of the network visualizing the 2000+ companies, their key individuals and financial organizations was confirmed by our EIT ICT Lab collaborators but proved too complex for visual exploration of meaning in the network of relationships.

The simplified network of co-locations and their most connected actors in Figure 3 (across all node categories, i.e. individuals, companies and investors) shows the top 10 percent of nodes according to their betweenness value.

Figure 3 Top 10% of individual, companies and investors connecting EIT ICT Labs co-location cities according to their betweenness in 2013.

Figure 4 shows the network visualization of the full sample that includes the presence of companies, key individuals and financial firms located in the San Francisco Bay Area, as well as within of EIT ICT Labs ecosystem. This expanded sample shows a vastly larger ecosystem with a significantly larger number of nodes, and links (number of nodes is 35,389 and total number of links is 51,106). The potential expansion of relational capital through which information, talent and financial resources could flow to and from companies in the EIT ICT Labs co-location cities is illustrated.

Figure 4 San Francisco Bay Area as a seventh EIT ICT Labs co-location city according to year 2013 sample

4.3 Sensemaking with interaction and feedback

Sensemaking discussions note ecosystem events – the existence of companies, individuals and financing firms, as well as their relationships to each other. The discussions also address impact – the growth in size of the ecosystem and its different actors over time and the differences in mobility factors among the co-location cities. During this study, revealing the structure of the EIT ICT Labs innovation ecosystem enabled sensemaking conversations, in which both researchers and EIT ICT Labs representatives participated.

The review of Figure 3 resulted in the insight that only a small proportion of the individuals and financial firms in the EIT ICT Labs overall network exhibit relationship capital that spans more than one EIT ICT Labs co-location city. The review of Figure 3 also prompted the observation that financial organizations occupy key connector roles between the companies in various co-location cities, leading to sensemaking discussions about additional opportunities to include financial organizations in the EIT ICT Labs' programs and activities. Initially, EIT ICT Labs had not emphasized the role of financial organizations in its ecosystem: for example, none of its core or affiliate partners were financial organizations. However, with the data-driven approach and the data that inherently included connections through financing organizations, the role of financing organizations became evident, introducing more collaboration between EIT ICT Labs and financial organizations.

Visual examination of the network including SF Bay Area as the hypothetical seventh EIT ICT Labs co-location city provided an example of a "what-if" question for policy makers and decision makers. This analysis (Figure 4) validated the strong role of SF Bay Area in the European venture-backed innovation ecosystem, also indicated by the high degree values for American corporate investment entities and US-based venture capital investors. The force-directed layout algorithm positions nodes with greatest connectivity in the center of the network, and thus we see the SF Bay Area at the center of the network and EIT ICT Labs co-location cities on the periphery. The notable green belt accentuates the presence of financial actors as mobility enablers in connecting the companies and key individuals of the EIT ICT Nodes to the SF Bay Area. Sensemaking discussions about Figure 4 led to conversations about ways in which EIT ICT Labs programs could establish a presence in the Bay Area to enable and accelerate mobility factors – events whose impact would lead to new coalitions and the development of relationships through which information, talent and financial resources could flow.

As summarized in Table 4, sensemaking and interpreting the visualizations support the understanding of the ecosystem, provide the contextual view of the larger innovation ecosystem in which EIT ICT Labs operates and allowing for interaction and feedback using the IETF framework. Our investigation of actors and relationships in this specific innovation landscape focuses on revealing relationships of individuals in the network (the mobility of knowledge and talent), as well as financing firms (the mobility of financial resources), as measures of the transformation potential of an innovation ecosystem. These measures of mobility are considered key in deriving insights that can contribute toward decisions to support the network orchestration of relationships among companies, individuals and financial firms. Hence, the findings are interpreted with that specific context in mind. The growth of the ecosystem indicates mobility of individuals, companies and financial firms entering into the ecosystem; the key metrics indicate increasing potential of relationships as resources for mobility; and the role of financial firms as well as key individuals is seen as a key mobility enabler. The potential for mobility within Europe, as well as between Europe and the Bay Area reveals opportunities for greater access to resources for growth.

Table 4 Sensemaking of research findings (evidence of ecosystemic linkages and actors)

Findings *	***Sensemaking***
Growth over time of EIT ICT Labs Ecosystem sample (Table 2)	Describes growth of the overall EIT ICT Labs ecosystem: The increased numbers of individuals, companies and financial firms; *mobility of entities entering into the ecosystem*
Change over time in key metrics for co-location cities (Table 3)	Reveals changes in the EIT ICT Labs ecosystem over time: The increased value of degree reflects new connections to the cities. The increased value of betweenness reflects new connections between the companies, financial firms and individuals with locational relationships to these cities. Paris and Berlin are the largest and best-connected clusters. *New connections are resources for mobility* of individuals (knowledge) and financing.
Key individuals, companies and financial firms as resources for mobility (Figure 2)	*Shows the central role of financial actors as resource-brokers and key mobility enablers.* The relationship connections, shown by green lines, linking the financial actors to companies and individuals, highlight this. These are created by their relationships with entities in multiple cities. Fewer blue nodes and lines, indicating limited roles of individuals in connecting the ecosystem.
Top 10% of individual, companies and investors connecting EIT ICT Labs co-location cities according to their betweenness (Figure 3)	Indicates the importance of financial actors, companies and a limited number of key individuals in connecting the ecosystem. *The potential mobility of information, talent and financial resources through financial actors', companies', and individuals' relationships, shown by links.* The numbers of key individuals with multi-node connections remains low, though has increased from 2011 to 2013.
San Francisco Bay Area as a seventh EIT ICT Labs co-location city (Figure 4)	Adds the 7th node expanded the network Showed the sheer size as well as the central role of San Francisco Bay Area *Potential mobility of financial resources and key individuals in an extended network*

Note: A new city, Trento, was added in 2012 and the geographical areas of each city were re-defined in 2012, hence the exact comparisons are not possible

5 Discussion

This study proposes that data-driven network visualizations play a role in generating insights for orchestrating innovation ecosystems. At the core are (1) the component of visualizations and the data-driven processes toward those, as well as (2) the component of understanding them in the context of innovation ecosystem transformation, which are conducted using the IETF construct. The two components are tightly linked. As uncertainty around the network activity and its value is inherently high (Ritvala and Salmi, 2010), one benefit of using IETF for EIT ICT Labs is measuring and tracking its networked nature (structure, key actors, patterns of interest, and flows of interaction) as empirical evidence for interactions and feedback, which allows for shared vision and understanding about the entity being orchestrated.

5.1 Data-driven network visualizations

Our six-location modelling of the EIT ICT Labs co-location cities resulted in network metrics and geospatial social network visualizations, describing the growth and evolution of the EIT ICT Labs ecosystem. Highlighting the relationships of companies, key individuals, and financial organizations – and their potential contributions to the mobility objective – reveals the existing network of relationship capital into which the activities of the EIT ICT Labs can be integrated. Consistent with the understanding of emergent structures that are only visible after they have emerged (Padgett and Powell, 2013), it is assumed that additional nodes and links are in emergent states within the existing innovation ecosystem that described the EIT ICT Labs.

Our ecosystemic, evidence-based method uses relationships to reflect the mobility factor of ecosystem development; these and the overall values of this study are validated through interactions and feedback with leaders in the EIT ICT Labs, through informal, in-depth discussions. In these discussions, the observed changes in degree and betweenness over time were attributed to the programmatic activities of EIT ICT Labs, such as research activities along mobility objectives, action lines and meetings as catalysts. Program leaders interpreted the increased relationships and networks for mobility to the process of creating the EIT ICT Lab program, and used their interpretations also for targeting some identified key individuals for potential collaboration as well as for planning for international outreach enhancing mobility, especially to Silicon Valley/San Francisco Bay Area.

EIT ICT Labs representatives affirmed the value of geospatial representations, though the insights from the network metrics and their interpretation were considered challenging. The use of analysis and network level snapshots over a three-year period was seen to provide a valuable baseline for updating measurements with the emphasis on the issue of mobility. It was seen to contribute a shared understanding of the complex issue of evolution and changes of an ecosystem. Future use of such indicators for understanding, monitoring, managing and evaluating the impact of the activities in the context of EIT ICT Labs was encouraged in these discussions. Especially as the co-location cities reflect a newly established network, one of the contributions of this research can be seen to be toward establishing a visible description for EIT ICT Labs' mobility objective, creating shared vision and communicating to broad audiences about its organizational objectives and accomplishments.

5.2 Operationalizing IETF for network orchestration

The network visualizations allowed for observations of the network as the whole and for the identification of individual actors, such as those in financing, and it allowed for targeted orchestration. Hence, our research supports the understanding of orchestration as a set of evolving actions (Paquin and Howard-Grenville, 2013). For the interact and feedback elements of IETF, data-driven network visualizations can reflect the structure of an innovation ecosystem at a single point of time; they can also show the evolution of an ecosystem's actors and their relationships over time, corresponding to the opportunity for examining relationships and interactions (Halinen et al. 2012) and showing how network participants build valuable positions through their activities (Powell et al., 1996). Using IETF can contribute to the establishing the legitimacy of the EIT ICT Labs and communicating widely about it (Möller and Rajala, 2007). For example, two EIT ICT Labs representatives have used the network visualizations created in this study in management meetings as well as in conference presentations (Turpeinen, 2011; Jonker, 2013).

In dynamic ecosystems, networks compete against networks; and leading actors, as network orchestrators, must help entities in the ecosystem understand their roles in the network and collaborate for integrated synergy with common vision that creates value for the entire network (Ritala et el., 2013). Skilful network orchestration enables shared vision about the whole ecosystem, as well as for individuals' egocentric networks, corresponding to the value flows from targeted and directed connections arranged by an orchestrator (Paquin and Howard-Glenville, 2013). Our operationalization of IETF in this study highlights the importance of shared vision that is collectively realized and continually updated (Hagel and Seely Brown, 2005), extending the process studies of change in organizations that "conceptualize change as a succession of events, stages, cycles or states in the development or growth of an organization" (Van De Ven and Poole, 2005, p. 1389) to innovation ecosystems.

We recommend the development of improved methods for managing the volume, velocity and variety of data (McAfee and Brynjolfsson, 2012). To transform an innovation ecosystem, we suggest that the network orchestrator should simultaneously: (1) facilitate the network; and (2) enable the individual actors and their activities.

We invite researchers, program managers and policy makers to explore and embrace the possibilities of combining a variety of data sources, for data-driven network visualizations as well as for other evidence about ecosystems and their actors and interactions. In addition, we see that to allow for faster and deeper insights, metrics and their representations must move beyond static snapshots. Interactive visualizations introduce means to apply the methods and tools of visual analytics (Keim, Kohlhammer and Ellis, 2010) for decision-making support.

5.3 Limitations

During this research, we collaborated actively with the representatives of EIT ICT Labs in order to seek fundamental insights on (1) the most representative data sources available to support the analysis, (2) selecting the most appropriate metrics and network visualization parameters, and (3) ways to use the visualizations in a meaningful way in EIT ICT Labs management processes. These discussions led to deeper understanding about the limitations related to evidence-based approach presented here, as well as potential improvements for analysis processes (for example, for data sampling) and suggested questions for guiding the process.

Naturally, the limitations of this research as well as the applicability of the results and subsequent recommendations are amplified with the use of case study approach and its inherent challenge of generalization. In addition, the use of action research components further limits generalization with the context and time specificity of interpretations conducted throughout the research. For example, the participants' voluntary participation and openness to collaboration with research partners can be seen to have impacted the results, but the extent and the nature of the impact remain imprecise.

Importantly, the value of the data-driven insights on how an ecosystem emerges and evolves depends strongly on both the quantity and quality of data. The novelty of our results comes from the use of socially constructed data that is (almost) real-time, providing information that we find to be difficult to obtain through other sources. With data openly available on the Internet and curated through social media practices, important contextual insights can be provided to augment program-specific and internal data collecting and reporting practices. It is possible that some relevant data was not included. Some of the potential biases in the data were counter-balanced by its large quantity. Further, the applied data curation processes optimized the quality and accessibility of this data. For example, the increase in the number of companies related to EIT ICT Labs from 2011 to 2012 may have partially been due to the changes in the sampling procedure used for those two years as the initial sample dataset was expanded to include Trento.It is also worth noting that English language bias of the dataset might have been partially responsible for the extremely strong representation of SF Bay Area actors in the expanded sample.

Additionally, it is not clear at this time whether growth in the number of companies from 2012 to 2013 reflects growth in the availability of data that includes the companies or growth in actual activities of companies represented by this sample of data. Also why the growth of the subset used for this research differs from the growth of the overall dataset is not clear. The details of such biases, which may be inherent in socially constructed data or might correlate with larger societal and/or business trends, are not well documented to date, and they present an opportunity for further study. Still, the patterns that emerge from large quantities of data can be seen produce insights about the character of phenomena represented by the data.

Though we agree with Kohlhammer et al. (2012) that visualization and visual analytics are vital for informed decision-making and policy modelling in a highly complex information environment overloaded with data and information, we do not advocate using network visualizations as the only evidence for decision-making or policy setting. The literacy of decision makers in visual analytics and network metrics is just beginning to emerge. Most managers are not accustomed to reading network visualizations, and the metrics behind them are not yet common knowledge. Our experience emphasized the important responsibility of action researchers to educate about the methodologies at the same time as presenting the results and to communicate the data and the analytical processes in a way that makes sense for the decision makers.

6 Conclusions

In this study, we utilized the Innovation Ecosystems Transformation Framework to investigate and explain the complexities of innovation and to create a shared understanding and insights toward possibilities for network orchestration within the case environment of EIT ICT Labs. We demonstrate that data-driven network visualizations offer a powerful approach for providing evidence-based information when talking about ecosystems, their structures, key actors and interactions, revealing their context and the potential for novel structures and relationships, especially in this case of operationalizing mobility as relational capital. For EIT ICT Labs as an example, the network visualizations and the network metrics show key roles of financial organizations as well as the impact and size of the Bay Area/Silicon Valley ecosystem.

Accordingly, resulting network metrics and visualizations provide a significant step forward in addressing the call for better understanding of network orchestration (Paquin and Howard-Grenville, 2013), simultaneously highlighting the possibilities of data-driven decisions (McAfee and Brynjolfsson, 2012) for addressing the complexities of ecosystems and the use of multiple methods for understanding the processes over time (Bizzi and Langley, 2012). For EIT ICT Labs, the visualizations provided a description of the complexities of its ecosystem; the metrics describe some changes in the dynamics of its ecosystem.

Data-driven visualizations can support the development of insights needed to orchestrate transformations of ecosystems, recognizing that activities orchestrated through individual actors of a network impact the whole network with the potential to leverage the relationship complexities of innovation. We claim that our approach not only describes and visualizes the innovation network, but also provides insights for enhancing methods for the development, controllability and manageability of innovation networks, as it shows the individual and influential actors, through which transformation can take place.

Acknowledgements

The authors express their gratitude to Rahul C. Basole for suggestions on the visualizations and to Marko Turpeinen of EIT ICT Labs for feedback and continued support. The authors would also like to thank the reviewers for their constructive comments on the manuscript. This research has been supported in part by the Finnish Funding Agency for Innovation, Tekes.

References

Basole, R.C. and Rouse, W.B. (2008) ‘Complexity of service value networks: Conceptualization and empirical investigation’, *IBM Systems Journal*, Vol. 47, No. 1, pp.53-70.

Basole, R.C., Russell, M.G., Huhtamäki, J. and Rubens, N. (2012), ‘Understanding Mobile Ecosystem Dynamics: A Data-Driven Approach’, *Proceedings of 2012 International Conference on Mobile Business (ICMB 2012)*, Delft, Netherlands, pp. 17–28. Available at: http://aisel.aisnet.org/icmb2012/15/ (Accessed 25 September 2013).

Benbasat, I., Goldstein, D.K. and Mead, M. (1987) 'The Case Research Strategy in Studies of Information Systems', *MIS Quarterly* Vol. 11, No. 3, pp.369-386.

Bizzi, L. and Langley, A. (2012) 'Studying Processes In and Around Networks', *Industrial Marketing Management*, Vol. 41, No. 2, pp.224-234.

Brydon-Miller, M., Greenwood, D. and Maguire, P. (2003) Why Action Research? *Action Research*, 1(1), pp.9–28. Available at: http://arj.sagepub.com/content/1/1/9

Card, S.K., Mackinlay, J.D. & Shneiderman, B., 1999. *Readings in Information Visualization: Using Vision to Think*, San Francisco, CA: Morgan Kaufmann Publishers.

Christensen, C. (1997) *The Innovator's Dilemma*, Boston, MA: Harvard Business Press.

Cunningham, P. and Ramlogan, R. (2012) 'The Effects of Innovation Network Policies'. *Compendium of Evidence on the Effectiveness of Innovation Policy Intervention*, Manchester Institute of Innovation Research, Manchester Business School, University of Manchester, http://www.innovation-policy.net/compendium/section/Default.aspx?topicid=23

Dhanaraj, C. and Parkhe, A. (2006) 'Orchestrating Innovation Networks', *Academy of Management Review*, Vol. 31, No. 3, pp.659-669.

Durst, S. and Poutanen, P. (2013), 'Success Factors of Innovation Ecosystems - Initial Insights from a Literature Review', *Proceedings of Co-Create 2013: The Boundary-Crossing Conference on Co-Design in Innovation*, 16-19 June, 2013, Aalto University, Espoo, Finland.

Easley, D. and Kleinberg, J. (2010) *Networks, Crowds, and Markets: Reasoning About a Highly Connected World,* Cambridge University Press, New York, NY, USA.

Freeman, L.C. (2009) 'Methods of Social Network Visualization', in Meyers, R.A. (Ed.), *Encyclopedia of Complexity and System Science*, Springer, Berlin.

Graversen, K.E. (2003) *Human Capital Mobility—A Comparable Knowledge Indicator*, Science and Technology Indicators in the Nordic Countries, OECD Report.

Green, D.G. and Sadedin, S. (2005) 'Interactions Matter—Complexity in Landscapes and Ecosystems', *Ecological Complexity*, Vol. 2, No.2, pp.117-130.

Hadhazy, A. (2011) 'Visualization Tools Can 'See' Through a Forest of Data', *TechNewsDaily* [online] 10 February. Available at: http://www.technewsdaily.com/2053-visualization-tools-can-see-through-a-forest-of-data.html

Halinen, A., Medlin, C.J. and Törnroos, J-Å. (2012) 'Time and Process in Business Network Research', *Industrial Marketing Management*, Vol. 41, No. 2, pp.215-223.

Hagel, J. and Seely Brown, J. (2005) *The Only Sustainable Edge*, Harvard Business School Press, Boston.

Hwang, V.W. and Horowitt, G. (2012) *The Rainforest: The Secret to Building the Next Silicon Valley,* Regenwald, Los Altos Hills, CA, USA.

Jonker, W. (2013, December 5) EIT ICT Labs: Create for Value. Presented at the iMinds The Conference 2013, Brussels. Available at: http://www.slideshare.net/iMinds/eit-ict-labs-external-presentation-dec-2013

Keim, D., Kohlhammer, J. and Ellis, G. (Eds.). (2010) *Mastering the Information Age - Solving Problems with Visual Analytics*. Eurographics Association. Available at: http://www.vismaster.eu/book/

Kohlhammer, J., K. Nazemi, T. Ruppert and D. Burkhardt (2012) 'Toward Visualization in Policy Making', *IEEE Computer Graphics and Applications*, Vol. 32, No. 5, September-October, pp.84-89.

Krackhardt, D. and Hanson, J.R. (1993) 'Informal Networks: The Company Behind the Charts', *Harvard Business Review*, Vol. 71, No. 4, pp.104-111.

Liu, Y.-Y., Slotine, J.-J. and Barabasi, A.-L. (2011) 'Controllability of Complex Networks', *Nature*, Vol. 473, No. 7346, pp.167–173.

McAfee, A. and Brynjolfsson, E. (2012) 'Big Data: The Management Revolution', *Harvard Business Review*, October, pp.61-68.

McKinsey. (2011) *Big Data: The NextFfrontier for Innovation, Competition andPproductivity*. [online] McKinsey Global Institute, Overall Presentation, October. Available at: http://www.jegi.com/sites/default/files/McKinsey_Presentation.pdf

Möller, K. and Rajala, A. (2007) 'Rise of Strategic Nets: New Modes of Value Creation', *Industrial Marketing Management*, Vol. 36 No. 7, pp.895–908.

Noack, A. (2009) 'Modularity Clustering is Force-directed Layout', *Physical Review E*, Vol. 79, No. 2, p.8. doi:10.1103/PhysRevE.79.026102

Nykänen, O., Salonen, J., Haapaniemi, M. and Huhtamäki, J. (2008) A Visualisation System for a Peer-to-Peer Information Space, *Proceedings of OPAALS 2008: The 2nd International OPAALS Conference on Digital Ecosystems*, October 7-8, 2008, Tampere, Finland, pp. 76–85. Available at: http://matriisi.ee.tut.fi/hypermedia/events/opaals2008/articlelist.html#opaals2008-article14

Padgett. J. and Powell, W.W. (2013) 'The Problem of Emergence', in Padgett. J. and Powell, W.W. (Eds.), *The Emergence of Organizations and Markets*, Princeton University Press, Princeton, NJ, USA.

Paquin, R. and Howard-Grenville, J. (2013) 'Blind Dates and Arranged Marriages: Longitudinal Processes of Network Orchestration', *Organization Studies*, Vol. 34, No. 11, pp.1623-1653.

Powell, W.W., Koput, K. W. and Smith-Doerr, L. (1996) 'Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology', *Administrative Science Quarterly*, Vol. 41, No. 1, pp.116–145.

Powell, W.W. and Owen-Smith, J. (2013) 'An Open Elite', in Padgett. J. and Powell, W.W. (Eds.), *The Emergence of Organizations and Markets*, Princeton University Press, Princeton, NJ, USA.

Ritala, P., Armila, L. and Blomqvist, K. (2009) 'Innovation Orchestration Capability—Defining the Organization and Individual Determinants', *International Journal of Innovation Management*, Vol. 13, No. 4, pp. 569-591.

Ritala, P., Agouridas, V., Assimakopoulos, D. and Gies, O. (2013) 'Value Creation and Capture Mechanisms in Innovation Ecosystems: A Somparative Case Study', *International Journal of Technology Management*, Vol. 63, No. 3/4, pp.244–267.

Ritvala, T. and Salmi, A. (2010) 'Value-based Network Mobilization: A Case Study of Modern Environmental Networkers', *Industrial Marketing Management*, Vol. 39, No. 6, pp.898–907.

Rizova, P. (2006). 'Are You Networked for Successful Innovation?', *MIT Sloan Management Review*, Vol. 47, No. 3, pp.49-55.

Rubens, N., Still, K., Huhtamäki, J. and Russell, M.G. (2010) *Leveraging Social Media for Analysis of Innovation Players and Their Moves*, mediaX White Paper, Stanford University.

Russell, M.G. and Smith, M.A. (2011) 'Network Analysis of Regional Ecosystem of Afterschool Programs', *Afterschool Matters*, Spring, pp.1-11.

Russell, M.G., Still, K., Huhtamäki, J., Yu, C. and Rubens, N. (2011) Transforming Innovation Ecosystems through Shared Vision and Network Orchestration, *Proceedings of Triple Helix IX Conference*, July 2011, Stanford University.

Saxenian, A. (2007) *The International Mobility of Entrepreneurs*. Berkeley University Papers. Available at: http://people.ischool.berkeley.edu/~anno/Papers/International_Mobility_of_Entrepreneurs.pdf

Southeastern Minnesota Initiative Fund (1995) *Regional Development Planning and Evaluation Report*, Connect Consultants International, Inc.

Still, K., Huhtamäki, J., Russell, M.G. and Rubens, N. (2012) Paradigm Shift in Innovation Indicators — From Analog to Digital, *Proceedings of 5th ISPIM Innovation Forum*, 9-12 December, 2012, Seoul, South Korea.

Turpeinen, M. (2011) What Kind of Questions in Innovation Ecosystems Insist Visualization? Mobility Analysis in the Context of European Innovation Ecosystem. Presented at the Visualizing Innovation Ecosystems Workshop, MindTrek 2011, Tampere, Finland. Available at: http://www.mindtrek.org/2011/visualizing-innovation-ecosystems

Van De Ven, A.H. and Poole, M.S. (2005) 'Alternative Approaches for Studying Organizational Change', *Organization Studies*, Vol. 26, No. 9, pp.1377-1404.

Walthne, K.H. and Heide, J.B. (2004) 'Relationship Governance in a Supply Chain Network', *Journal of Marketing*, Vol. 68, No. 1, pp.73-89.

Wasserman,S. and Faust, K. (1994) *Social Network Analysis: Methods and Applications,* 1st ed., Cambridge University Press, New York, NY.

Wellman, B. (1988). 'Structural Analysis: From Method and Metaphor to Theory and Substance', in Wellman, B. and Berkowitz, S.D. (Eds.), *Social Structures: A Network Approach*, Cambridge University Press, New York, NY, pp.19-61.

Welser, H.T., Gleave, E., Fisher, D. and Smith, M. (2007) 'Visualizing the Signatures of Social roles on Online Discussion Group', *The Journal of Social Structure*, Vol. 8, No. 2 [online]. Available at: http://www.cmu.edu/joss/content/articles/volume8/Welser/

Wind, J., Fung, V. K. K. and Fung, W., (2008) 'Network Orchestration: Core Competency in a Borderless World', in J. Wind, V.K.K. Fung, and W. Fung (Eds.), *Competing in a Flat World: Building Enterprises for a Borderless World*,Wharton University Publishing, Upper Saddle River, NJ.

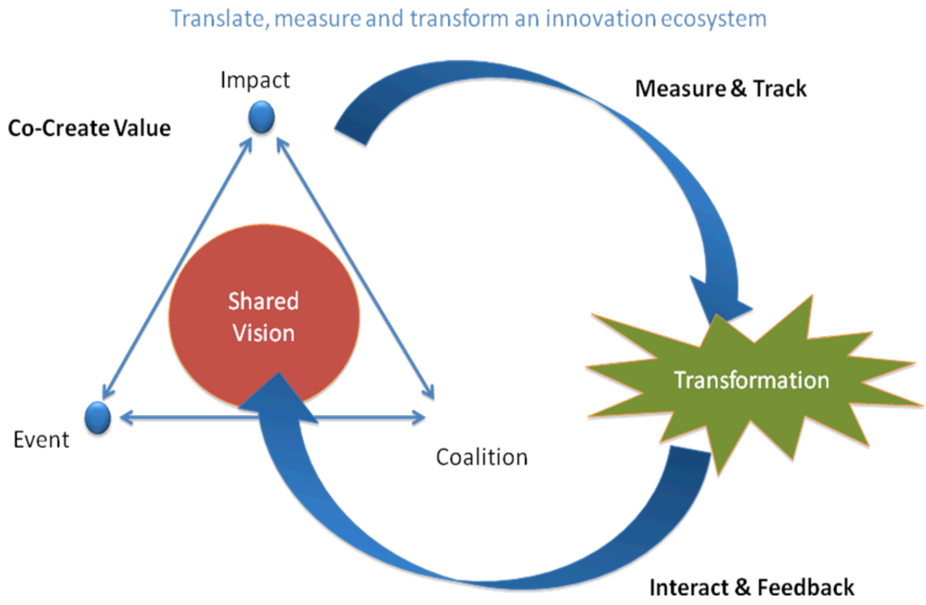

Figure 1 Innovation Ecosystem Transformation Framework (IETF)

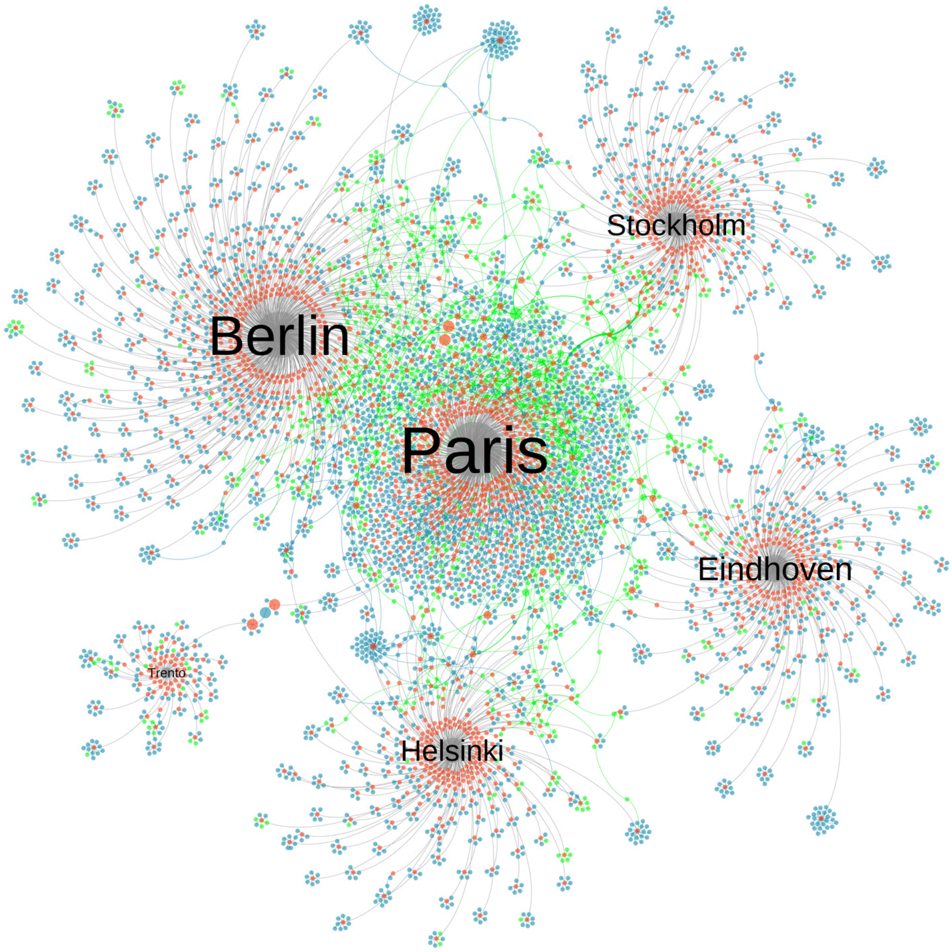

Figure 2 Key individuals, companies and financial firms as resources for mobility in 2013: highlighting the roles of Paris and Berlin in the ecosystem, and also the role of financial firms (green) as enablers for mobility

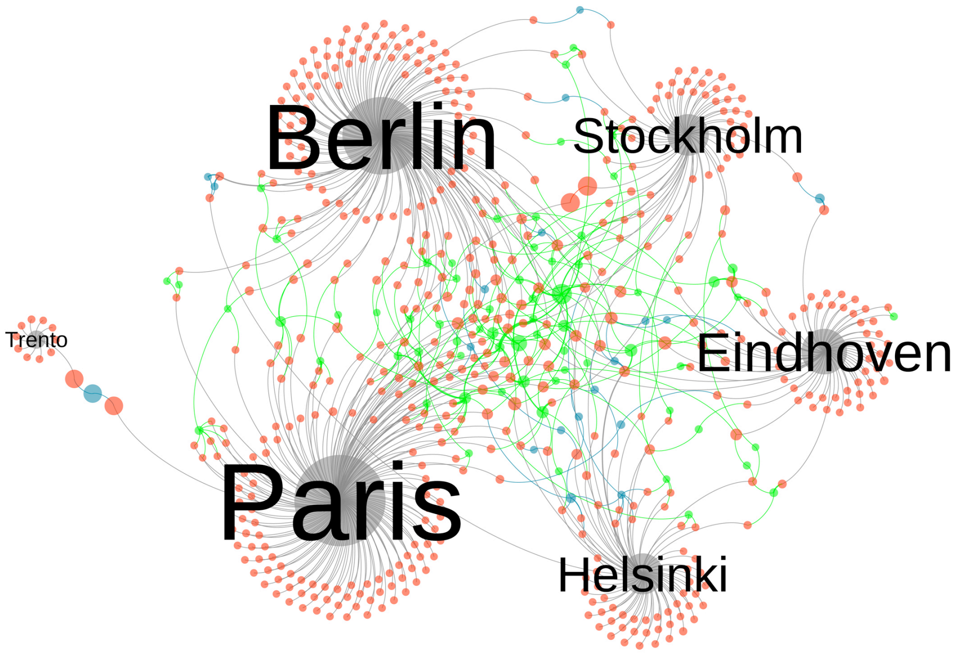

Figure 3 Top 10% of individual, companies and investors connecting EIT ICT Labs co-location cities according to their betweenness in 2013: highlighting the role of financial firms (green) as enablers for mobility

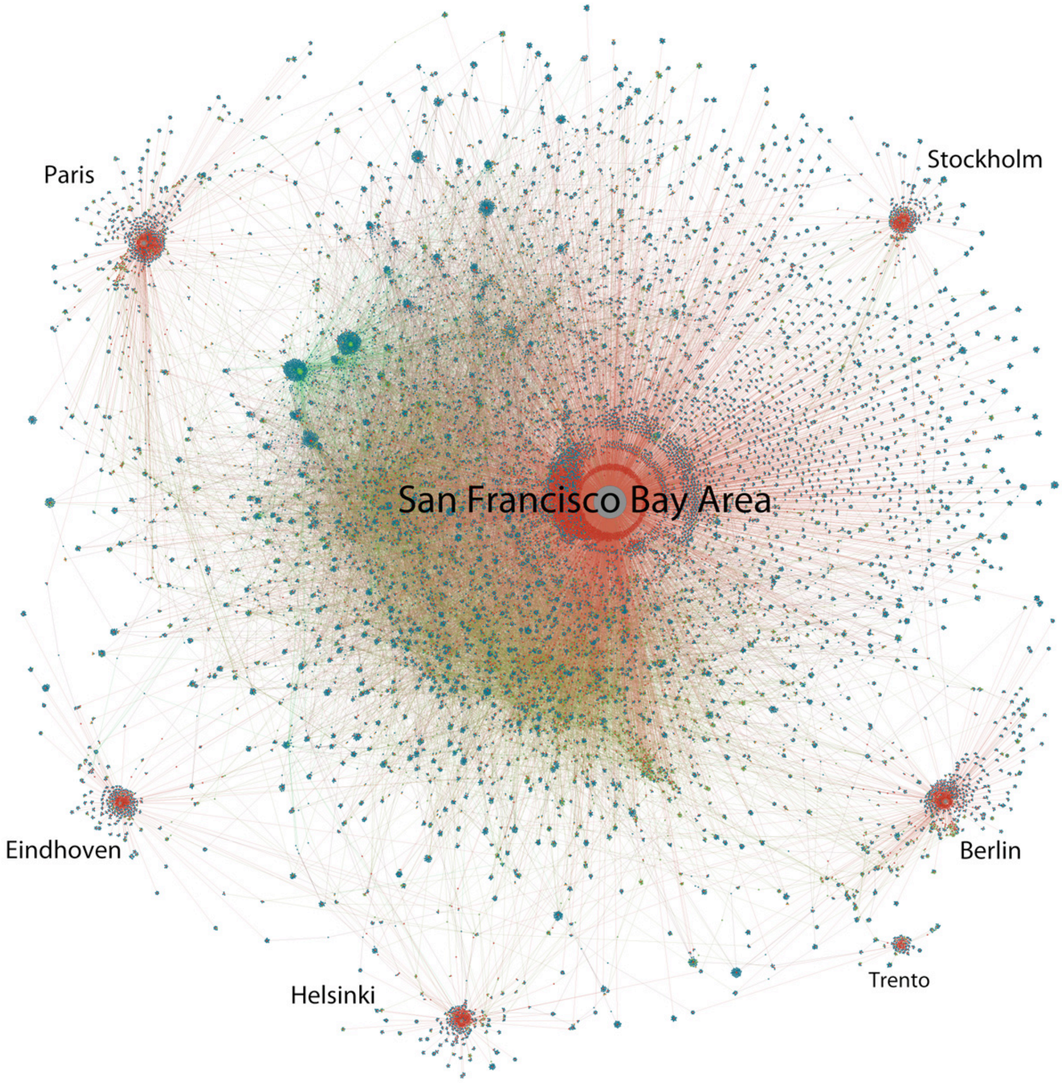

Figure 4 Figure 4 San Francisco Bay Area as a seventh EIT ICT Labs co-location city according to year 2013 sample: highlighting the possibilities of extended network for mobility